

Option F: Food Chemistry

CDO IB Chemistry SL

- **Food and Nutrients**

- Foods –
- Nutrients -
 - They are divided into six main groups:
 - Proteins
 - Carbohydrates
 - Lipids
 - Vitamins
 - Minerals
 - water.

- **Carbohydrates**

- Simple carbohydrates –
 - Contain a carbonyl group
 - Have between
 - Monosaccharides can undergo condensation reactions to

- **Carbohydrates: Glucose**

- Can exist as a straight chain isomer or as a ring compound:

- **Proteins**

- Large macromolecules made up of
- The amino acids bond to each other through condensation reactions resulting in the formation of a polypeptide in which

- **Example**

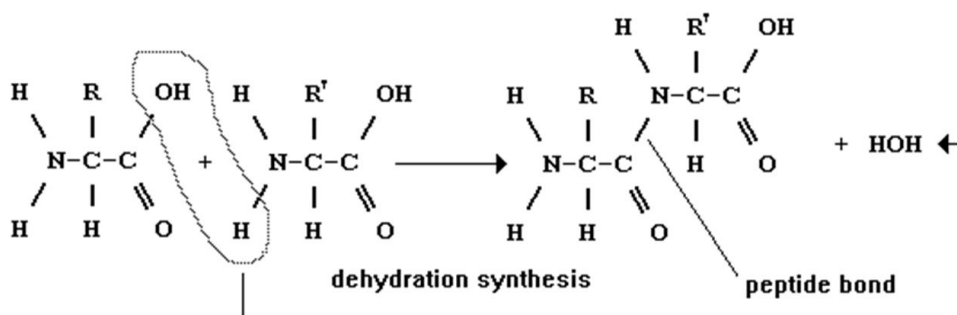
- Give the molecular formula of the molecule, X, shown and explain to which food group it belongs.

- **Example**

The molecule in the previous example can react with another molecule in a condensation reaction to form the compound, Y, below. Work out the molecular formula of Y and give the structure of the molecule, Z, that must react with X to form Y.

- **Proteins**

Synthesis of a Dipeptide from two amino acids (R and R'):



note that the bonds around the central carbon are arranged in a tetrahedron resulting in the final conformation of the peptide chain being even more convoluted than suggested above.

- **Lipids (Fats and Oils)**

- Fats and oils - triesters (triglycerides) formed from the

- Fats –

- Oils –

- Chemical difference

- Fats contain saturated

- Oils are unsaturated, containing at least one.

- **Fats and Oils**

- The long-chain fatty acids that make up the bulk of the mass of a triglyceride molecule may be divided into two categories:

-

-

-

-

- **Structure of Fatty Acids**

- Saturated –

- They contain the

- Unsaturated -

- They do not contain the maximum

- **Fats and Oils, Liquids or Solids**

- Saturated fatty acids will tend to

- Mono- and poly-unsaturated

- **Degree of crystallisation**

- Degree of crystallisation- is a property of solidification

- Three main factors that affect the melting point of a fat:

- relative
 - degree of
 - nature of the

- **Effect of relative molecular mass**

- Increasing the relative molecular
 - The rise in melting point is due to an increase in the number and combined strength of the

- **Effect of Unsaturation**

- Unsaturation (C=C bonds) in the hydrocarbon chain –
 - The greater the number of double bonds

- **Effect of Geometrical Isomerism**

- Unsaturated fatty acids can exist in two forms: cis and trans.
 - cis –
 - trans -

- **Trans Isomer**

- Carbon chain remains
 - strength of
 - have a higher melting point than their

- **Choice of Fat for Purpose**

- Fats and oils are chosen for
 - Example:

- **Stability**

- Rancidification - process by which fats, oils and other

- Saturated fats are more stable than unsaturated fats.

- Due to the

- **Oxidation with atmospheric oxygen (auto-oxidation)**

- Fats will go rancid
 - Due to their reaction with oxygen in the air causing them to break

- **Oxidation with atmospheric oxygen (auto-oxidation)**

- Mechanism involves the
 - Generally - more unsaturated fatty acids present in a fat,

- **Hydrogenation**

- Hydrogen gas is added across the double bond(s) present in mono- or, more usually, poly-unsaturated

- **Hydrogenation**

- Increases the saturated character of a fat

- Advantages –

- Disadvantages –

- **Photo-oxidation (reaction in light)**

- Free-radical-based reaction
 - High light intensities –

- **Hydrolysis (reaction with water, heat and enzymes)**

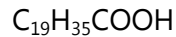
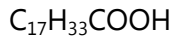
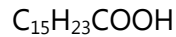
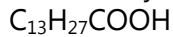
- Hydrolysis -

- Occurs when the

- It can also be

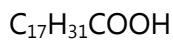
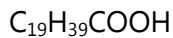
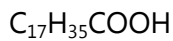
- **Example**

- The formulas of some fatty acids are shown below. Deduce the number of C=C bonds in each and classify them as saturated, mono-unsaturated or poly-unsaturated.



- **Example**

- Arrange the following fatty acids in order of increasing melting point (lowest first).



- **Shelf Life**

- The amount of time a

- If a food is past its shelf life,

- **Factors Affecting Shelf Life**

- Water content - a change of the water content can cause loss of

- pH -

- **Factors Affecting Shelf Life**

- Light - can lead to

- Temperature -

- Exposure to air –

- **Rancidity**

- Rancidity - a descriptive term relating to our

- Rancidity –

- **Hydrolytic rancidity**
 - Caused by the breaking
 - Occurs more rapidly with
 - Example of this process:
- **Fatty acids responsible for rancidity:**
 - Butanoid acid
 - Oleic acid in
 - Lauric acid in
- **Oxidative Rancidity**
 - Due to the oxidation of the fatty acid chains
 - by the addition of oxygen
 - Oily fishes –
 - Proceeds by a free radical mechanism
 - The greater the degree of unsaturation present

▪ **Prolonging shelf life and minimizing the rate of rancidity**

Processing	Packaging	Use of additives
<ul style="list-style-type: none"> •Refrigeration and freezing—storing dairy products at low temp. slows lipase hydrolysis •Reducing light levels by using colored glass or keeping in a dark place. •Radiation. Using gamma radiation or X-rays to destroy microorganisms. 	<ul style="list-style-type: none"> •Using an inert gas to minimize contact with oxygen. •Using hermetic sealing or low-gas permeability packaging film. •Keeping jars full to minimize the amount of air in the headspace above oil. •Sealing in tin cans. 	<ul style="list-style-type: none"> •Sodium sulfite, sodium hydrogensulfite, and citric acid -To delay onset of enzymatic browning •To cure meat, fix color and inhibit micro-organisms: sodium and potassium nitrite and nitrate. •To delay mold and bacterial growth in breads and cheeses: sorbic and propanoic acids and calcium and sodium propanoates. •To delay mold and bacterial growth in pickled meats and fish as well as adding flavor: ethanoic acid and benzoic acid. •Antimicrobial agents in fruit juices, carbonated drinks, pickles, and sauerkraut: sodium benzoate and benzoic acid.

- **Naturally Occurring Antioxidants**

- Antioxidants delay the onset or slow down the rate at

- Naturally occurring antioxidants include:

- Vitamin C (ascorbic acid):
 - Vitamin E (tocopherols):
 - β -carotene:
 - Selenium:

- **Synthetic Antioxidants**

- Common structures found in synthetic antioxidants

- Phenolic group
 - Tertiary butyl group

- Both of these groups are free radical scavengers, meaning they react with and remove

- **Antioxidants in Food**

- PROS**

- Naturally occurring vitamins C, E, and carotenoids reduce the risk of cancer and heart disease by inhibiting the formation of free radicals.
 - Vitamin C is vital for the production of hormones and collagen.
 - β - carotene can act as a precursor for vitamin A synthesis and can also give margarine its yellow color.

- CONS**

- Synthetic antioxidants are thought to be less safe as they do not occur naturally.
 - Natural antioxidants are more expensive and less effective than synthetic antioxidants and can also add unwanted color and leave an aftertaste in food.
 - Policies regarding the safe use and labeling of food additives can be difficult to implement and monitor, especially in developing countries and across borders.

- **Antioxidants in Traditional Food**

- Vitamin C and carotenoids can be found in
- Flavonoids:
 - natural
 - Found in
 - Have been linked to lowering levels of LDL (low density lipoprotein)

- **Food Color**

- A food has color because substances are able to absorb and reflect light from the visible region of the electromagnetic spectrum.
- The substances that give food its
- Natural colorants found in
- Synthetic food-grade

- **Analyzing Color From Spectra**

- Visible light wavelength:
- ROYGBIV→

- **Pigments**

- Pigments that occur naturally:

Anthocyanins	Carotenoids	Chlorophyll	Heme
<ul style="list-style-type: none"> •Most widely occurring pigment in plants. •Responsible for the pink, red, purple, and blue colors in fruits and vegetables, including cranberries, blueberries, strawberries, and raspberries. 	<ul style="list-style-type: none"> •Most widespread pigments in nature (mostly produced by algae). •Act as a precursor for vitamin A synthesis. •Colors range from yellow to red/orange. It is found in bananas, carrots, tomatoes, watermelon, peppers, and saffron. •Red astaxanthin (complexed to a protein) is responsible for the blue or green color of live lobsters and crabs and the pink color of salmon and flamingos. 	<ul style="list-style-type: none"> •Pigments found in green plants that are required for photosynthesis . 	<ul style="list-style-type: none"> •Myoglobin is responsible for the purple-red color of fresh meat.

- **Synthetic Colorants (Dyes)**

- Food additives are
 - In some parts of the world these are known as
- Countries have different regulations and
- Many dyes used in the past have been shown

- **Factors Affecting the Color Stability of Pigments**

- Changes in the structure of a molecule will
- These include:
 -
 -
 -
 -

- **Anthocyanins**

- Anthocyanins -
 - Have characteristic
- Principal pigments - responsible for the pink, red, blue and purple colours of many fruits and vegetables

- **Carotenoids**

- Alternate carbon to carbon
- Example: β -carotene—
- Carotenoids
- Most widespread pigment found in
 - Precursors of

- Transmit or reflect longer wavelengths of the visible spectrum (absorb in the blue-violet region) - have colours in the yellow-orange-red region. Carotenoids are present in bananas, carrots, tomatoes, watermelon, sweet peppers and saffron
- **Chlorophyll**
 - These are the major pigments in green plants responsible for harvesting light energy –
- **Heme**
 - Heme is the red pigment found in the
 - The heme in
- **Stability of pigment Colours**
 - Major factors affecting pigment colour are:
 -
 -
 -
 - presence of
- **Effects on anthocyanins**
 - $(A) \leftrightarrow (AH^+) \leftrightarrow (B) \leftrightarrow (C)$
 - In aqueous solution, anthocyanins exist in a
 - At low pH (1–3) -
 - pH is increased,
 - In basic conditions,

- **Effects on carotenoids**

- Due to the presence of a conjugated, multiple C=C double bond system, carotenoids are not only coloured
- When oxidised –

- **Effects on chlorophylls**

- Chlorophylls can be destabilised by high
 - In an alkaline solution
 - In an acidic solution
 - Adding a small amount of sodium hydrogencarbonate

- **Effect on Heme**

- If freshly cut meat is exposed to air
 - When oxygen in the air binds to the purple-red myoglobin (Mb) it forms oxymyoglobin (MbO₂) which is red –
 - Meat is left exposed to air for several days, the myoglobin and oxymyoglobin undergo auto-oxidation in which

- **Safety issues associated with dyes and Synthetic Colourants**

- Sunset Yellow (E110) - linked to
- Amaranth (E123) - banned in the USA for over

- The main problem facing society concerning food colourants is

- **Non-Enzymatic Browning of Food - Caramelization**

- Caramelisation -

- The rate of caramelisation can be increased by catalysis with a base ($\text{pH} > 9$) or an acid ($\text{pH} < 3$), as well as by

- Baked-egg dishes

- **Maillard Reaction**

- For foods

- Involves a reaction between the amino group of an amino acid and a

- Example of Maillard reaction:

- **The Texture of Food**

- Foods seem to be

- Dispersed system:

- Types of dispersed system:

- Suspension:
- Emulsion:
- Foam:

- **Genetically Modified Food (GM)**

Pros

- Plants can be made more resistant to disease, herbicides, and insect attack.
- Anti-cancer substances and increased amounts of vitamins could be incorporated and exposure to less healthy fats reduced.
- Can lead to soil, water, and energy conservation and improve natural waste management.

- **Genetically Modified Food (GM)**

CONS

- Genetically engineered genes may escape and contaminate normal crops with unknown effects.
- They may cause disease as the anti-biotic resistant genes could be passed to harmful microorganisms.
- Links to an increase in allergic reactions (mostly in the food processing).